AD-A105 376 ANDERSON ENGINEERING INC SPRINGFIELD MO F/G 13/13
NATIONAL DAM SAFETY PROGRAM. BURTON DUENKE NUMBER 3 LAKE DAM (M--ETC(U)
AUG 80 G WERTEPNY, D KERNS, S L BRADY DACW43-80-C-0073
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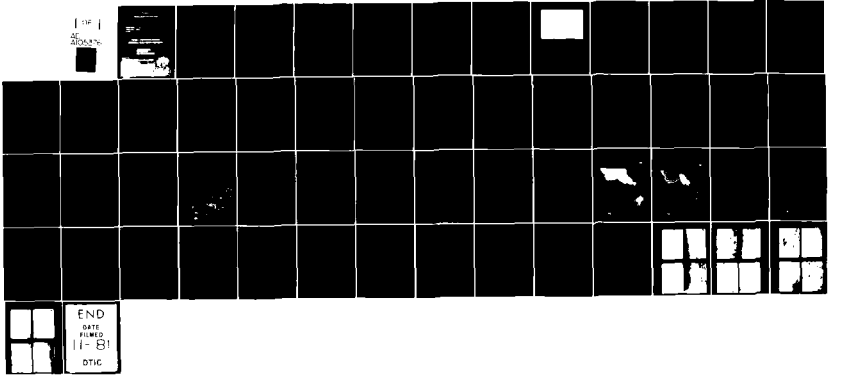

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. AD-A105376

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
Phase I Dam Inspection Report
National Dam Safety Program
Duenke, Burton Lake No. 3 (MO 31609)
Camden County, Missouri

5. TYPE OF REPORT & PERIOD COVERED
Final Report

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(a)
Anderson Engineering, Inc.

8. CONTRACT OR GRANT NUMBER(a)
DACW43-80-C-0073

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U.S. Army Engineer District, St. Louis
Dam Inventory and Inspection Section, LMSED-PD
210 Tucker Blvd., North, St. Louis, Mo. 63101

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army Engineer District, St. Louis
Dam Inventory and Inspection Section, LMSED-PD
210 Tucker Blvd., North, St. Louis, Mo. 63101

12. REPORT DATE
August 1980

13. NUMBER OF PAGES
Approximately 50

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)
National Dam Safety Program. Burton Duenke Number 3 Lake Dam, Osage-Gasconade River Basin, Camden County, Missouri. Phase I Inspection Report.

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for release; distribution unlimited.

(MO 31609)

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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☆ U.S. G.P.O. 1980-665-141/1299

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Burton Duenke No. 3 Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Burton Duenke No. 3 Lake Dam (MO 31609).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

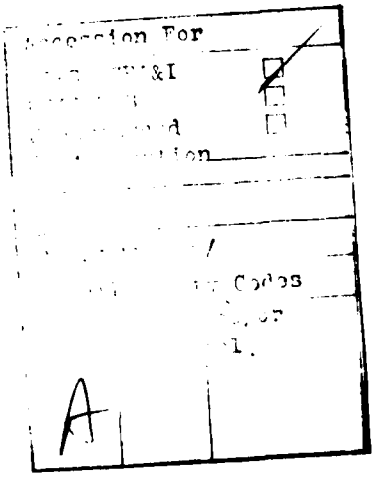
a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY SIGNED
Chief, Engineering Division
29 AUG 1980
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer
29 AUG 1980
Date



OSAGE-GASCONADE RIVER BASIN

BURTON DUENKE NO. 3 LAKE DAM

CAMDEN COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31609

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

June, 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Burton Duenke No. 3 Lake Dam
State Located: Missouri
County Located. Camden County
Stream: Tributary of Lake of the Ozarks
Date of Inspection: April 29, 1980

Burton Duenke No. 3 Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately one mile downstream of the dam. Located within this zone are a dwelling, 13 trailers, boat docks and a marina. The dam is in the intermediate size classification, since it is greater than 40 ft high but less than 100 ft high. The maximum storage capacity is greater than 50 ac-ft but less than 1000 ac-ft.

Our inspection and evaluation indicates that the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass 24 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of intermediate size with a high downstream hazard potential pass the PMF.

The 1 percent probability flood will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year.

The dam appears to be in good condition. Deficiencies visually observed by the inspection team were. (1) Some light brush on both faces of the dam; (2) Seepage area at the junction of the downstream slope and west abutment; (3) Erosion channel at east abutment and downstream slope contact; (4) Seepage area at and beyond the downstream embankment toe; and (5) Lack of wave protection for the upstream face of the embankment.

Another deficiency was the lack of seepage and stability analysis records.

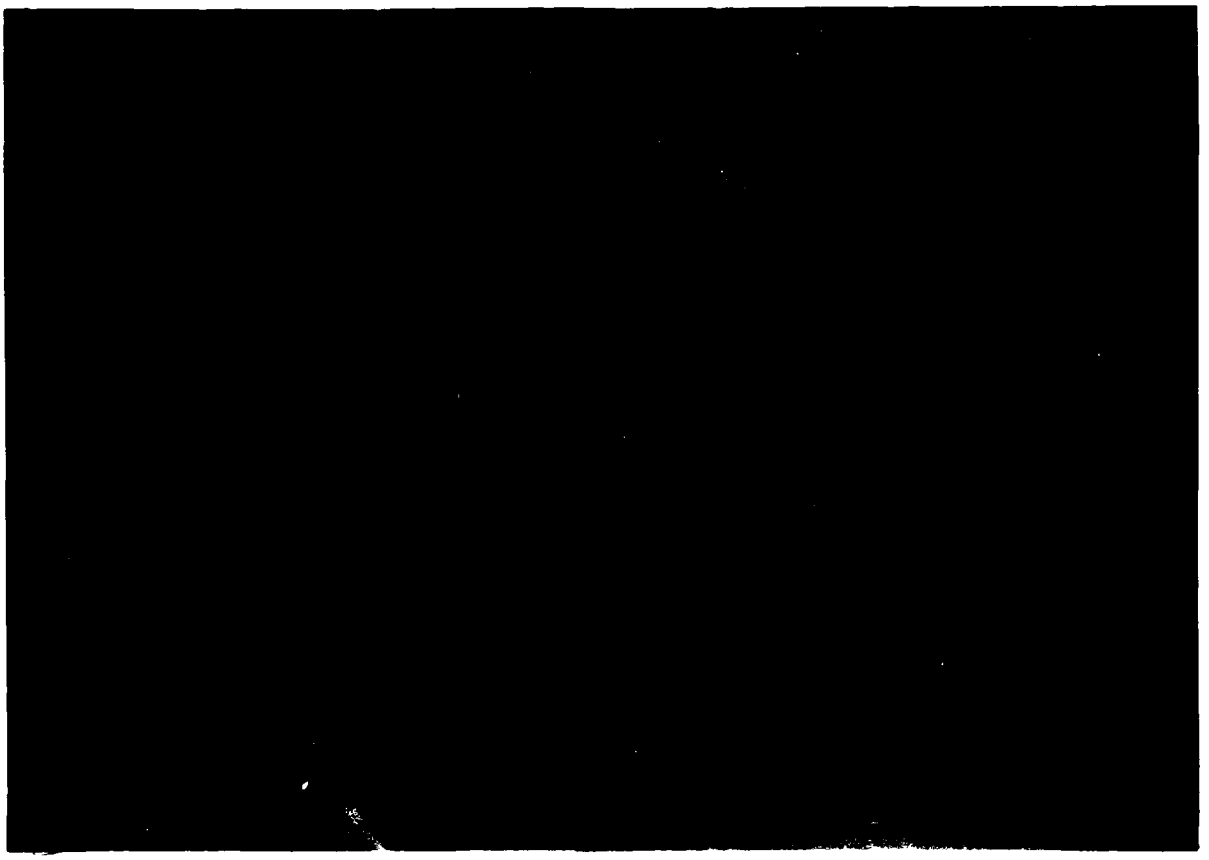
It is recommended that the owners take the necessary action without undue delay to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Gene Wertepny, P.E.
Hanson Engineers, Inc.

Dan Kerns, P.E.
Hanson Engineers, Inc.

Steven L. Brady, P.E.
Anderson Engineering, Inc.

Tom Beckley, P.E.
Anderson Engineering, Inc.



AERIAL VIEW OF LAKE AND DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

BURTON DUENKE NO. 3 LAKE DAM
MISSOURI INVENTORY NO. 31609

TABLE OF CONTENTS

APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority.

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Burton Duenke No. 3 Lake Dam in Camden County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT.

A. Description of Dam and Appurtenances:

Burton Duenke No. 3 Lake Dam is an earth fill structure approximately 47 ft high and 425 ft long at the crest. The appurtenant work consists of an 18 inch diameter uncontrolled corrugated metal pipe CMP spillway located near the east abutment.

Sheet 3 of Appendix A shows a plan profile and typical section of the embankments.

B. Location:

The dam is located in the North Central part of Camden County, Missouri on a tributary of Lake of the Ozarks. The dam and lake are within the Lake Ozark, Missouri 7.5 minute quadrangle sheet (Section 09, T39N, R16W - latitude 38°07.8'; longitude 92°41.8'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 45 ft and a maximum storage capacity of approximately 62 acre-ft, the dam is in the intermediate size category.

D. Hazard Classification.

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately one mile downstream of the dam. Located within this zone are a dwelling, 13 trailers, boat docks and a marina. Location of affected feature within the damage zone were verified by the inspection team.

E. Ownership.

The dam is owned by Tan-Tar-A Development, a part of Burton Duenke Development. The owner's address is P. O. Box 213-32, Osage Beach, Missouri 65065. Mr. Westhoff's telephone number is 314/348-2706.

F. Purpose of Dam:

The dam was constructed primarily for lakeside home and golf course development.

G. Design and Construction History:

No design information or plans are available. The dam was built by Tan-Tar-A Development Corporation with Mr. Wes Westhoff as project supervisor. The dam was constructed in 1971 by the work force and equipment of the Development Corporation.

Mr. Westhoff reported that a core trench about 20 feet wide was excavated to rock. The average depth of the trench was estimated to be 8 feet. The material for construction of the dam was obtained from the lake area. Compaction of the trench material and the embankment was by use of a D-8 dozer. There is no internal drainage or particular zoning of the embankment.

The spillway pipe was sized by Mr. Westhoff for a storm of reoccurance intervals of 30 years for the estimated drainage area. An Armco drainage design data card was used for this design.

No modifications to the dam have been reported since the initial construction.

H. Normal Operating Procedures:

All flows will be passed by the uncontrolled corrugated metal spillway pipe. Information obtained from the superintendent indicates that the dam has never been overtopped.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet and a 1 foot contour interval map obtained from the owner, is approximately 26.6 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through an uncontrolled spillway.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 801.0): 11 cfs

(3) Estimated Capacity of Primary Spillway: 11 cfs

(4) Estimated Experience Maximum Flood at Dam Site: Unknown

(5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(7) Gated Spillway Capacity at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level elevation of 798.00 for the invert of the spillway inlet pipe (elevation obtained from owner).

(1) Top of Dam: 801.0 feet (Ave.), MSL

(2) Principal Spillway Pipe Invert: 798.00 feet, MSL

(3) Emergency Spillway Crest: Not Applicable

(4) Principal Spillway Pipe Invert At Outlet: 796.93 feet, MSL

(5) Streambed at Centerline of Dam: 756.0 feet, MSL

(6) Pool on Date of Inspection: 793.6 feet, MSL

(7) Apparent High Water Mark: Unknown

(8) Maximum Tailwater: Unknown

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 710 feet

(2) At Principal Spillway Crest. 690 feet

(3) At Emergency Spillway Crest: Not Applicable

E. Storage Capacities:

(1) At Principal Spillway Crest: 51 acre-feet

(2) At Top of Dam. 62 acre-feet

(3) At Emergency Spillway Crest. Not Applicable

F. Reservoir Surface Areas:

(1) At Principal Spillway Crest. 3.5 acres

(2) At Top of Dam: 3.8 acres

(3) At Emergency Spillway Crest: Not Applicable

G. Dam:

(1) Type. Earth Fill

(2) Length at Crest: 425 feet

(3) Height: 47 feet

(4) Top Width: 40 feet

(5) Side Slopes: Upstream 3H:1V; Downstream 2H:1V and 4H.1V

(6) Zoning: Apparently Homogeneous

(7) Impervious Core: None

(8) Cutoff: Key trench to bedrock

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

(1) Type. Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway.

I.1 Principal Spillway:

(1) Location: Station 3 + 60 (near east abutment)

(2) Type. 18 inch diameter corrugated metal pipe

I.2 Emergency Spillway.

(1) Location. None

(2) Type. Not Applicable

J. Regulating Outlets:

There are no regulating facilities associated with this dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No design computations or reports for this dam are available. No documentation of construction inspection records are known to exist. To our knowledge there are no documented maintenance data.

A. Surveys:

No information regarding pre-construction surveys was able to be obtained. The inlet-invert of the 18 inch diameter CMP was used as a site datum for one survey. The invert elevation of 798.00 mean sea level elevation was obtained from the owner from a post-construction survey. This survey consisted of determining mean sea level elevations for the inverts of the owner's dams in the area.

B. Geology and Subsurface Materials:

The site is located in the west-central portion of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus and deep valleys. The most common bedrock types are dolomite, sandstone and chert. The "Geologic Map of Missouri" indicates that the bedrock in the area consists primarily of the Gasconade formation of the Canadian Series in the Ordovician System. The Gasconade formation is predominantly a light brownish-gray, cherty dolomite. In the central Ozarks region, the average thickness of the Gasconade is 300 feet. Caves and springs are common in this formation.

The publication "Caves of Missouri" indicates that fifteen known caves exist in Camden County; 3 of these caves are located within 10 miles of the site. In addition, three caves in adjacent Miller County and one cave in adjacent Morgan County are located within 10 miles of the site. The closest known cave is about 5 miles southeast of the site.

The "Geologic Map of Missouri" indicates a normal fault passing about 3 miles north of the site in a northwest-southeast direction. The Missouri Geologic Survey has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years.

The soils in the area of the dam are of the Clarksville-Fullerton-Talbott soil association. These soils have developed from cherty limestone and dolomite. The thickness of loessial deposits in upland areas may range from 2.5 feet to 5.0 feet.

Information from the Soil Conservation Service indicates that the soils in this area "consist of deep and moderately deep, well drained, moderately permeable soils that formed in clayey residium weathered from cherty dolomitic limestone bedrock." The predominant Clarksville soil consists of a yellowish-red very cherty, silty clay loam.

C. Foundation and Embankment Design:

No design computations are available. Seepage and stability analyses apparently were not performed as required in the guidelines. There is apparently no particular zoning of the embankment and no internal drainage features are known to exist.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for this dam were available. Based on a field check of spillway dimensions and embankment elevations, a check of the drainage area on U.S.G.S. quad sheets, and a contour map obtained from the owner, hydrologic analyses using U. S. Army Corps of Engineers guidelines were performed and appear in Appendix C, Sheets 1 to 9.

E. Structure:

There are no structures associated with Burton Duenke Dam No. 3.

2.2 CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION.

Normal flows are passed by the 18 inch diameter corrugated metal pipe located at the east abutment. No operating facilities exist.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the Recommended Guidelines for Safety Inspection of Dams were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTON

3.1 FINDINGS.

A. General:

The field inspection was made on April 29, 1980, The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steven L. Brady - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)
Gene Wertepny - Hanson Engineers, Inc. (Hydraulic Engineer)
Dan Kerns - Hanson Engineers, Inc. (Geotechnical Engineer)

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The dam appears to be generally in good condition. No sloughing of the embankment was noted. The horizontal and vertical alignments of the crest appeared good, and no surface cracking or unusual movement was obvious. The crest of the embankment was 40 feet wide and the average elvation was 801.0 MSL.

The upstream face of the embankment has a slope of 3H to 1V from the crest to the water surface. The slope of the embankment is generally gravel covered. The small gravel does not provide any significant wave protection. No serious erosion or sloughing was observed on the upstream face of the embankment. Although no tree growth was noted, some of the embankment was covered with small brush growth.

The downstream face of the embankment has a 2H to 1V from the crest to about 55 feet downstream and 4H to 1V on to the toe of the embankment. An erosion channel has formed at the junction of the east abutment-embankment contact. Minimal light brush and small tree growth were noted on the downstream face of the embankment. Seepage areas were observed at the west abutment-embankment contact about midway up the downstream face and at the top near the west abutment. Concentrated flow of approximately 1 gallon per minute was observed at both locations. Both of the seep areas were soft and marshy with a growth of cattails in the general area of the seep. No apparent discoloration of the water was observed. An additional seepage area was observed approximately 50 yards beyond the toe of the embankment. The seepage ($\pm$ 1/2 gpm) and surrounding marshy area contained iron oxide staining.

Shallow auger probes into the embankment indicate the dam to consist of a reddish-brown sandy clay with some silt and chert fragments.

No instrumentation (monuments, piezometers, etc.) was observed. No animal burrows were noted.

C. Appurtenant Structures:

C.1 Primary Spillway:

The approach area to the 18 inch diameter spillway pipe was clear. Approximately 4 inches of silt were observed at the outlet of the spillway pipe. No provisions for a trash or debris screen were provided for at the inlet. The spillway outlet channel is well away from the embankment. No significant erosion was noted in the outlet channel.

C.2 Emergency Spillway:

There is no emergency spillway associated with this dam.

D. Reservoir.

The watershed is generally grass and tree covered with mild to steep slopes. Construction of the adjacent golf course is associated with the sedimentation and erosion of the reservoir area. The golf course is scheduled for completion this spring. Future development includes lakeside home sites. A golf cart trail bridge has been constructed across the upper end of the reservoir. No sloughing or serious erosion was noted. Sedimentation of the reservoir does not appear to be significant and would be expected to reduce after the adjacent construction is completed.

E. Downstream Channel:

The downstream channel is generally wooded with moderate side slopes. The Lake of the Ozarks is located several hundred yards downstream of the dam.

3.2 EVALUATION.

The brush and undesirable vegetation growth on the dam can provide shelter for small animals and encourage burrowing. The seepage from the west abutment-downstream embankment contact, the toe of the embankment and downstream from the toe could adversely affect the stability of the dam. The erosion of the east abutment-downstream embankment could worsen and also affect the stability of the embankment. The seepage areas and erosional area should be investigated by an engineer experienced in the design and construction of dams.

Photographs of the dam, appurtenant structures, and the reservoir are presented in Appendix D.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no operating facilities associated with this dam. The pool is normally controlled by rainfall, runoff, evaporation, the capacity of the uncontrolled spillway pipe, and seepage from the reservoir.

4.2 MAINTENANCE OF DAM:

Information from the owner indicates that maintenance is performed on an as needed basis and is not scheduled on a set basis.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities for this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The erosional area of the east abutment-downstream embankment contact and the seepage areas at the west abutment-downstream embankment contact, the downstream toe and the seepage area beyond the toe are deficiences which should be corrected. Remedial measures should be investigated by an engineer experienced in the design and construction of dams. Subsequently these areas should be inspected periodically to detect any further erosion or seepage.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic design computations for this dam were available.

B. Experience Data:

The hydraulic and hydrologic analyses were based on: (1) a field survey of spillway dimensions and embankment elevations: and (2) an estimate of the pool and drainage areas from the U.S.G.S. quad sheet, and (3) a 1 foot contour interval map obtained from owner. The spillway operates occasionally and the owner reported the maximum flow to have been about midway of the spillway pipe. At the time of inspection, the pool level was approximately 4.4 feet below normal pool. No high water marks or indications of overtopping were observed.

Our hydrologic and hydraulic analyses using U. S. Army Corps of Engineers guidelines appear in Appendix C.

C. Visual Observations:

The approach channel to the spillway is clear. The spillway channel is well separated from the embankment, and spillway releases would not be expected to endanger the dam.

D. Overtopping Potential.

Based on the hydrologic and hydraulic analysis presented in Appendix C, the spillway will pass 24 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (intermediate size with high downstream hazard potential) pass the PMF, without overtopping. The structure will pass a 1 percent probability flood without overtopping.

The routing of the PMF through the spillway and dam indicates that the dam will be overtopped by .97 ft at elevation 801.97. The duration of the overtopping will be 8.0 hours, and the maximum outflow will be 629 cfs. The maximum discharge capacity of the spillway is 11 cfs. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

No design and construction data for the foundation and embankment were available. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

There are no operating records for this dam.

D. Post-Construction Changes:

There have not been any reported post-construction changes to the dam.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) Minor brush growth on the slopes of the embankment; (2) Erosion channel at east abutment-downstream embankment contact; (3) Seepage at west abutment-downstream embankment contact, (4) Seepage at and beyond the downstream embankment toe; and (5) Lack of wave protection for the upstream embankment face.

Another deficiency was the lack of seepage and stability analyses records.

The dam will be overtopped by flows in excess of 24 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will continue to deteriorate and possibly could become serious in the future. The items recommended in paragraph 7.2A should be pursued without undue delay.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no additional inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES.

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

(1) Spillway size and/or height of dam should be increased to pass the PMF. In either case, the spillway should be protected to prevent erosion.

B. O & M Procedures:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.

(2) The seepage areas at the downstream west abutment-embankment contact and at and beyond the downstream embankment toe should be investigated by an engineer experienced in the design and construction of dams. Remedial measures may be required. As a minimum, the marshy areas should be drained and monitored to determine if there is any increase in quantities and whether soil particles are being carried with the water.

(3) Erosional areas should be repaired and seeded.

(4) Wave protection should be provided for the upstream face of the dam.

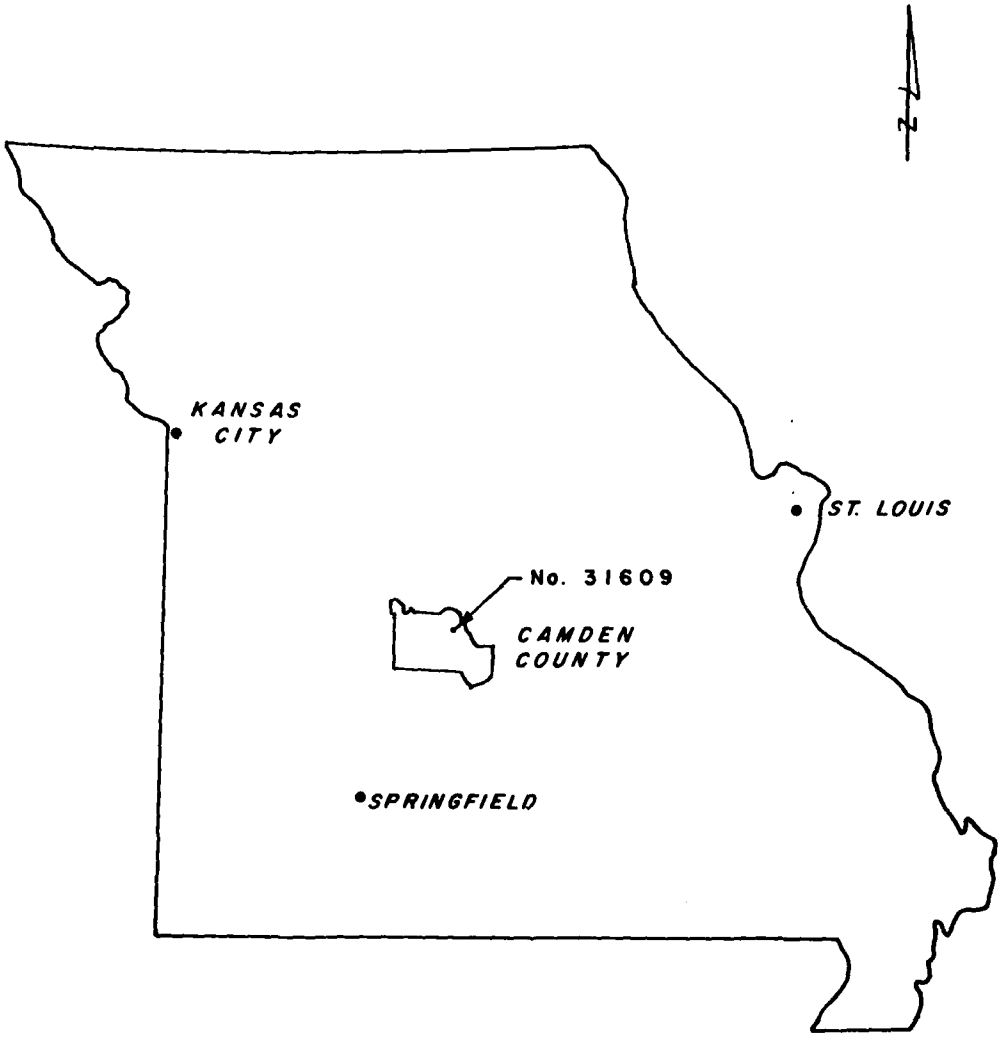
(5) The vegetative growth on the dam should be cut annually.

(6) A trash screen should be provided for the inlet of the spillway pipe.

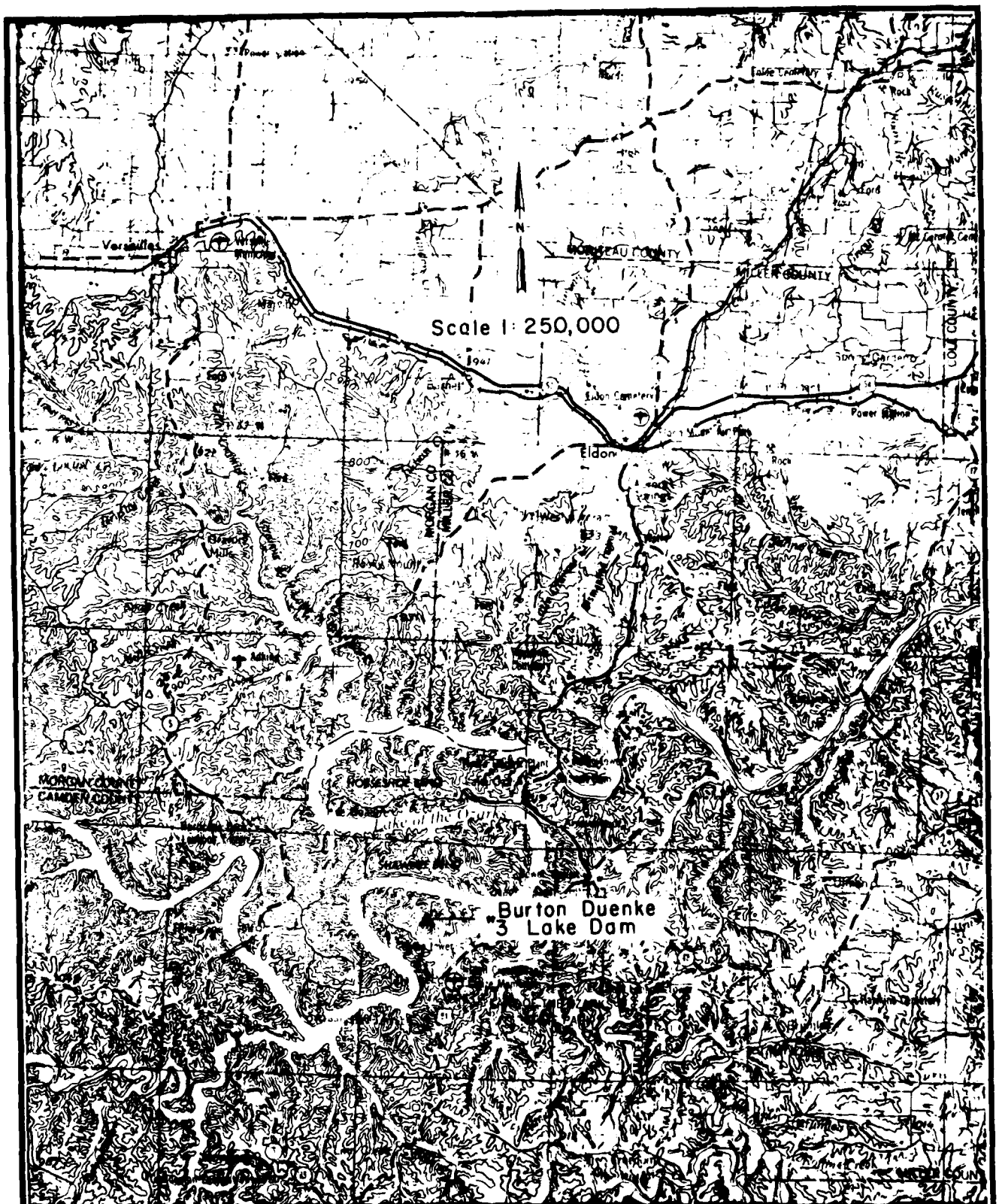
(7) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



LOCATION MAP



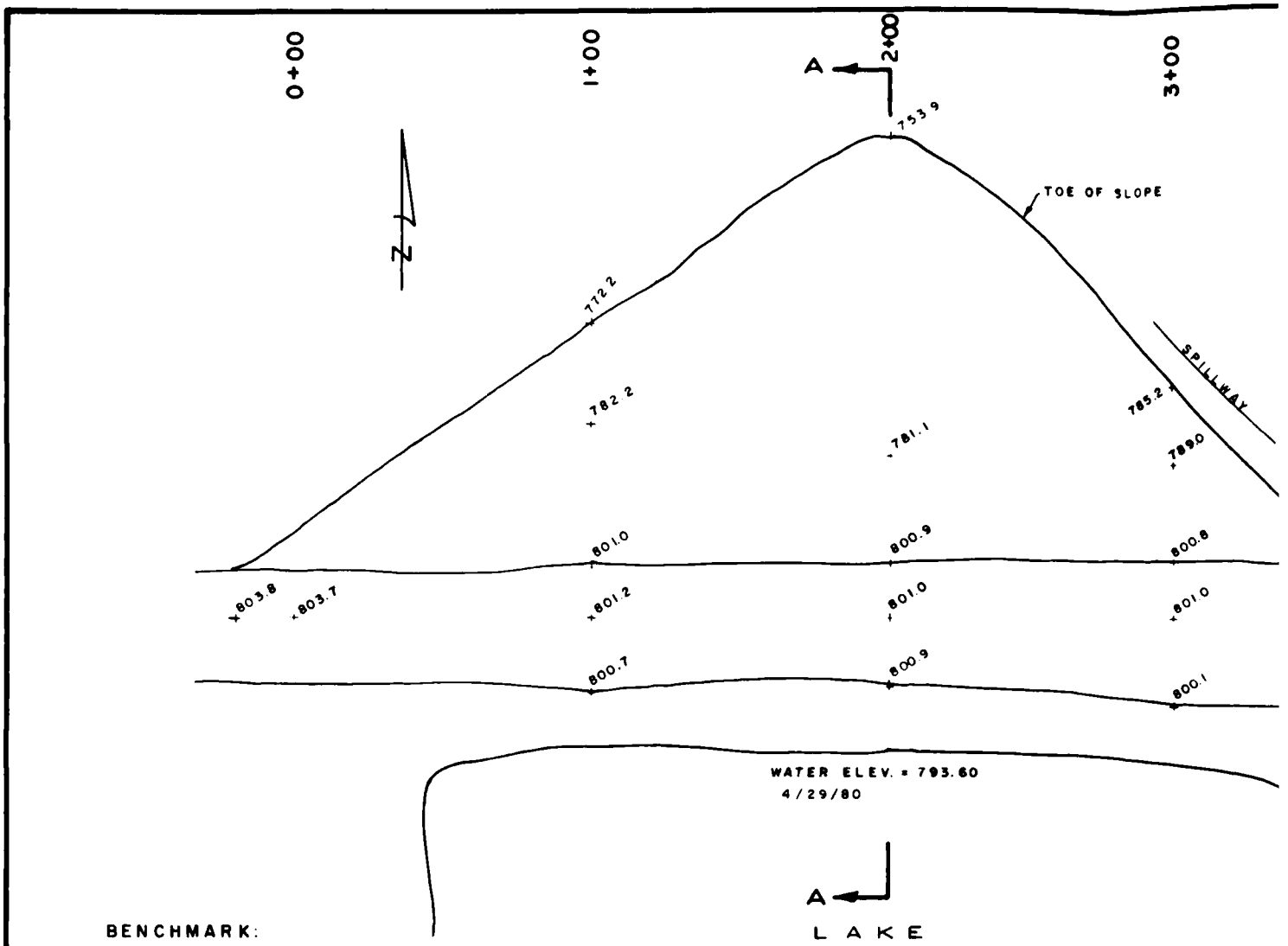
VICINITY MAP

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

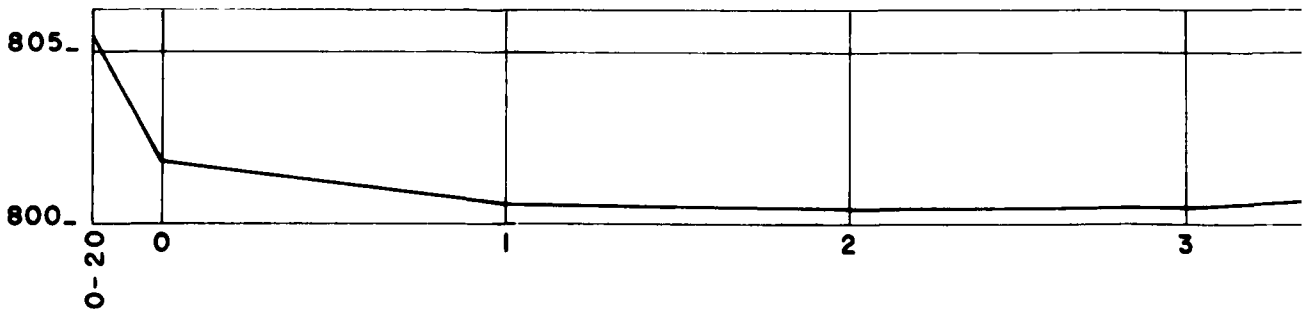
Burton Duenke #3 Lake Dam
Camden County, Missouri
Mo. I D. No. 31609

Sheet 2, Appendix A

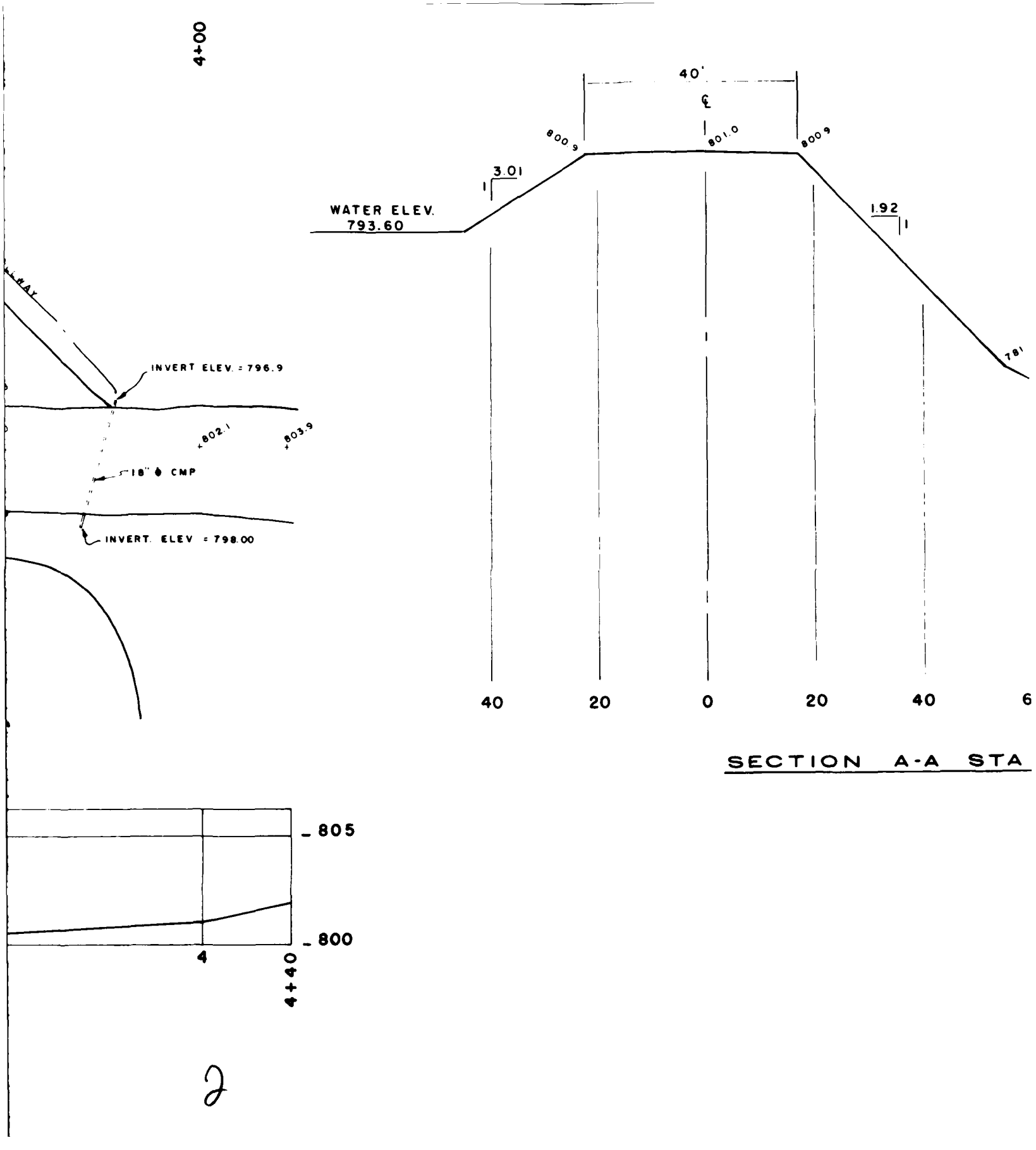


PLAN VIEW
SCALE: 1" = 50'

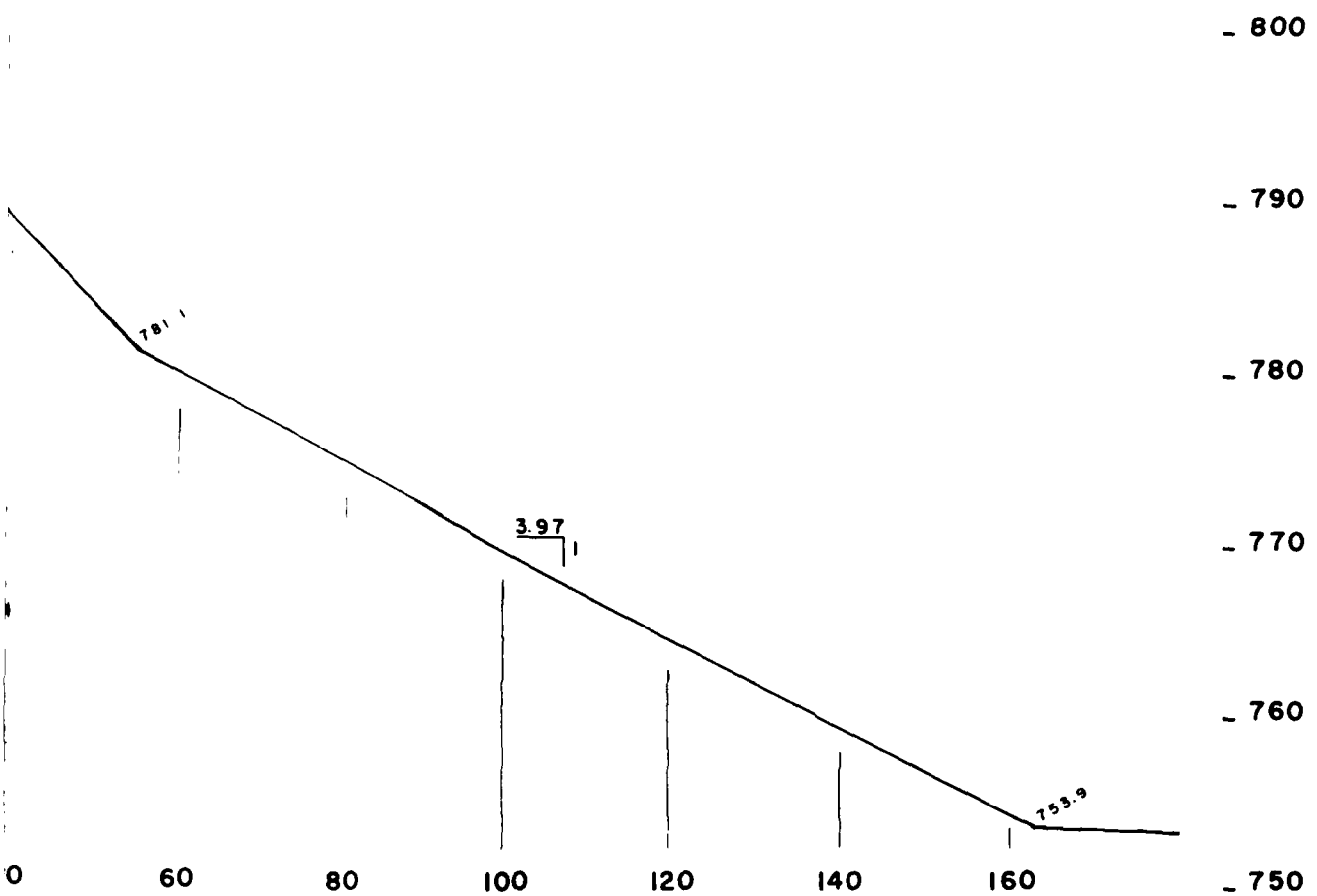
BENCHMARK:
18" ϕ CMP INVERT
ELEV. = 798.00



PROFILE


4+00
40'
℄
800.9
801.0
800.9
3.01
1
WATER ELEV.
793.60
1.92
1
781
INVERT ELEV. = 796.9
802.1
803.9
18" ϕ CMP
INVERT. ELEV = 798.00
40
20
0
20
40
6
SECTION A-A STA
805
800
4
4+40

2



A STA 2+00

SHEET 3 APPENDIX A

ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

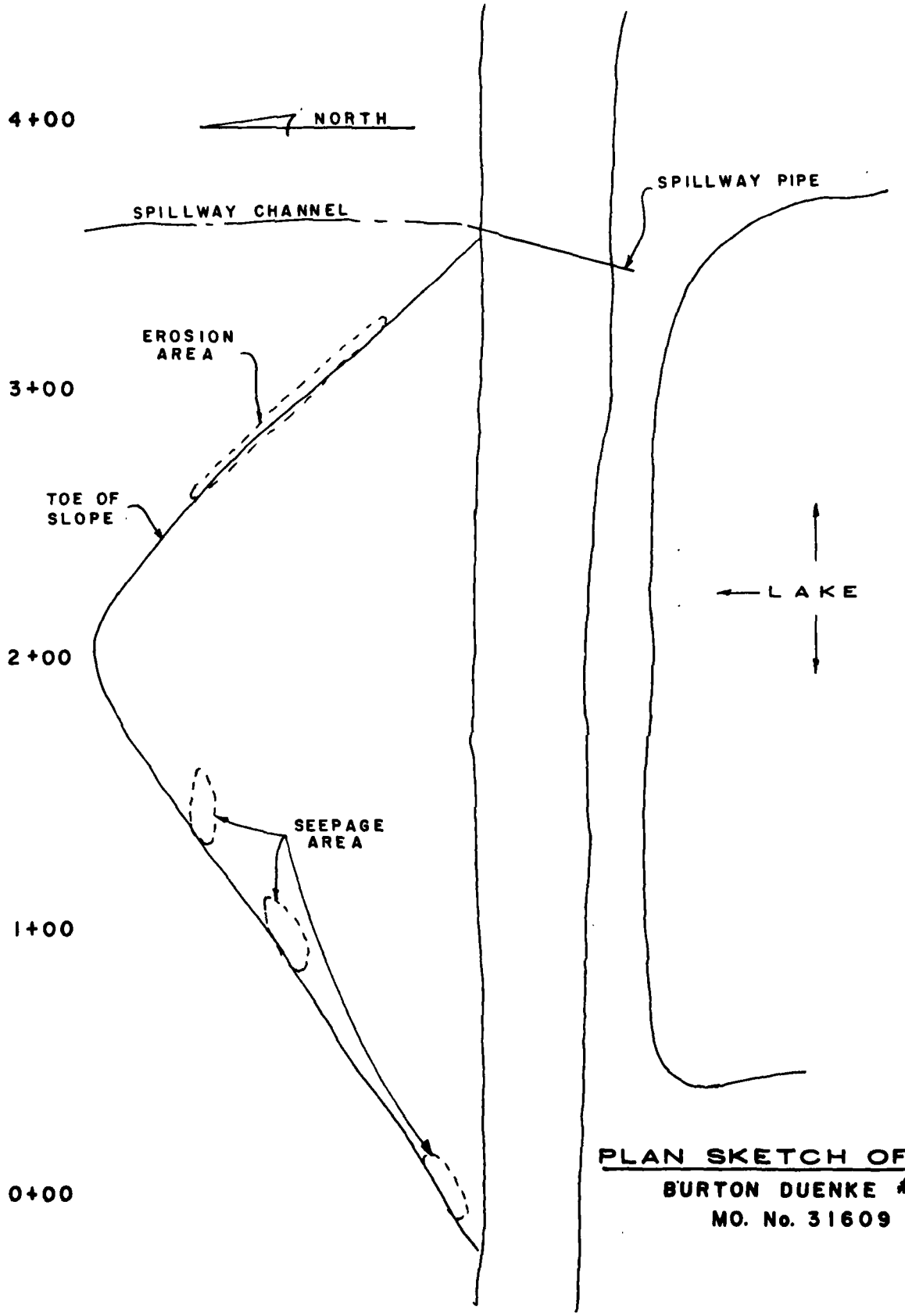
BURTON DUENKE #3

MO. No. 31609

PLAN & PROFILE

CAMDEN COUNTY, MO.

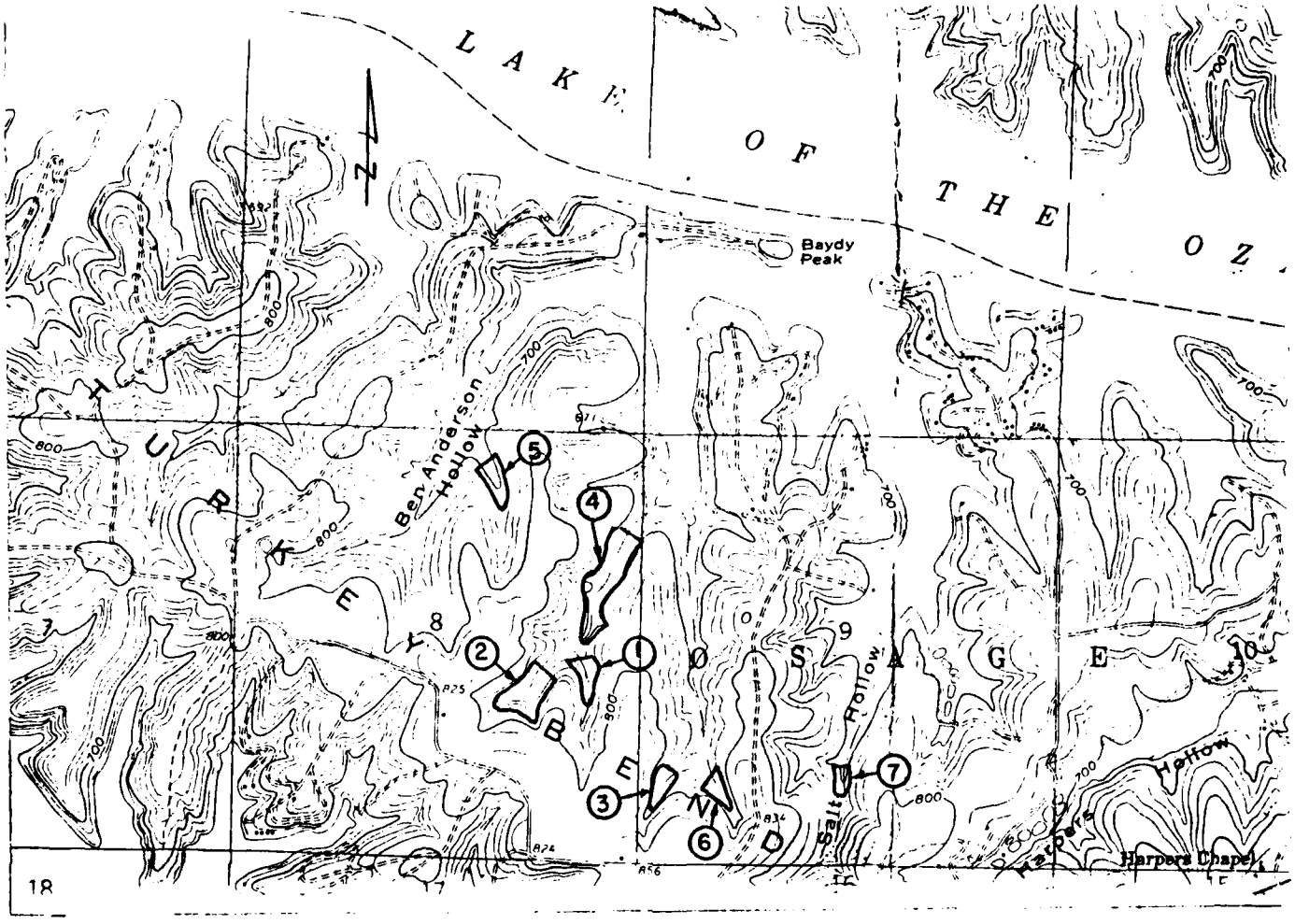
3



PLAN SKETCH OF DAM

BURTON DUENKE #3

MO. No. 31609



TOPOGRAPHIC MAP OF AREA DAMS

SCALE: 1:24,000

INDEX KEY

KEY No.	MO. I. D. No.	DAM NAME
1	31610	BURTON DUENKE #1
2	31611	BURTON DUENKE #2
3	31609	BURTON DUENKE #3
4	31713	BURTON DUENKE #4
5	—	—
6	—	—
7	—	—

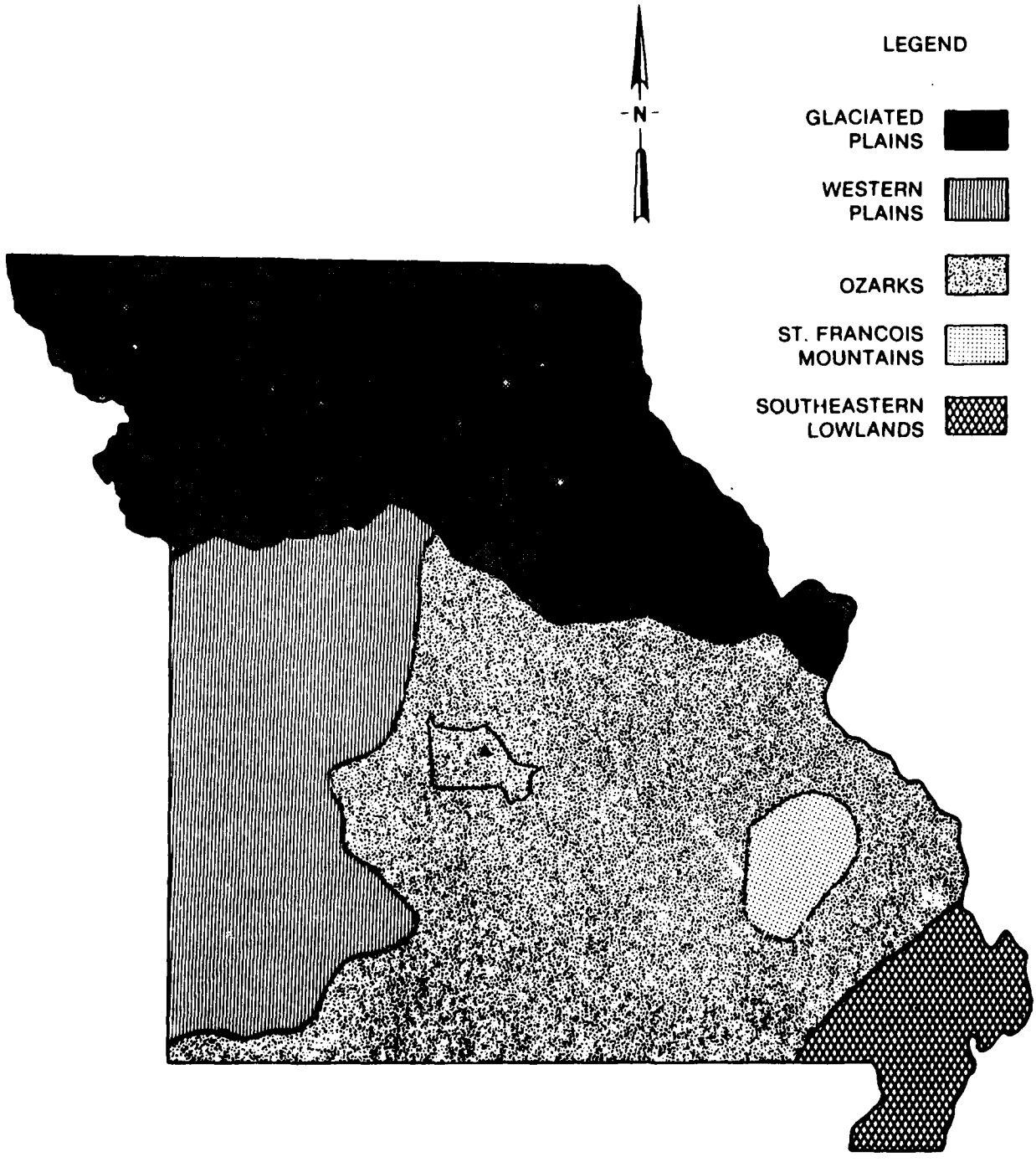
BURTON DUENKE #3 LAKE DAM

CAMDEN COUNTY, MISSOURI

MO. I. D. No. 31609

APPENDIX B

Geology and Soils



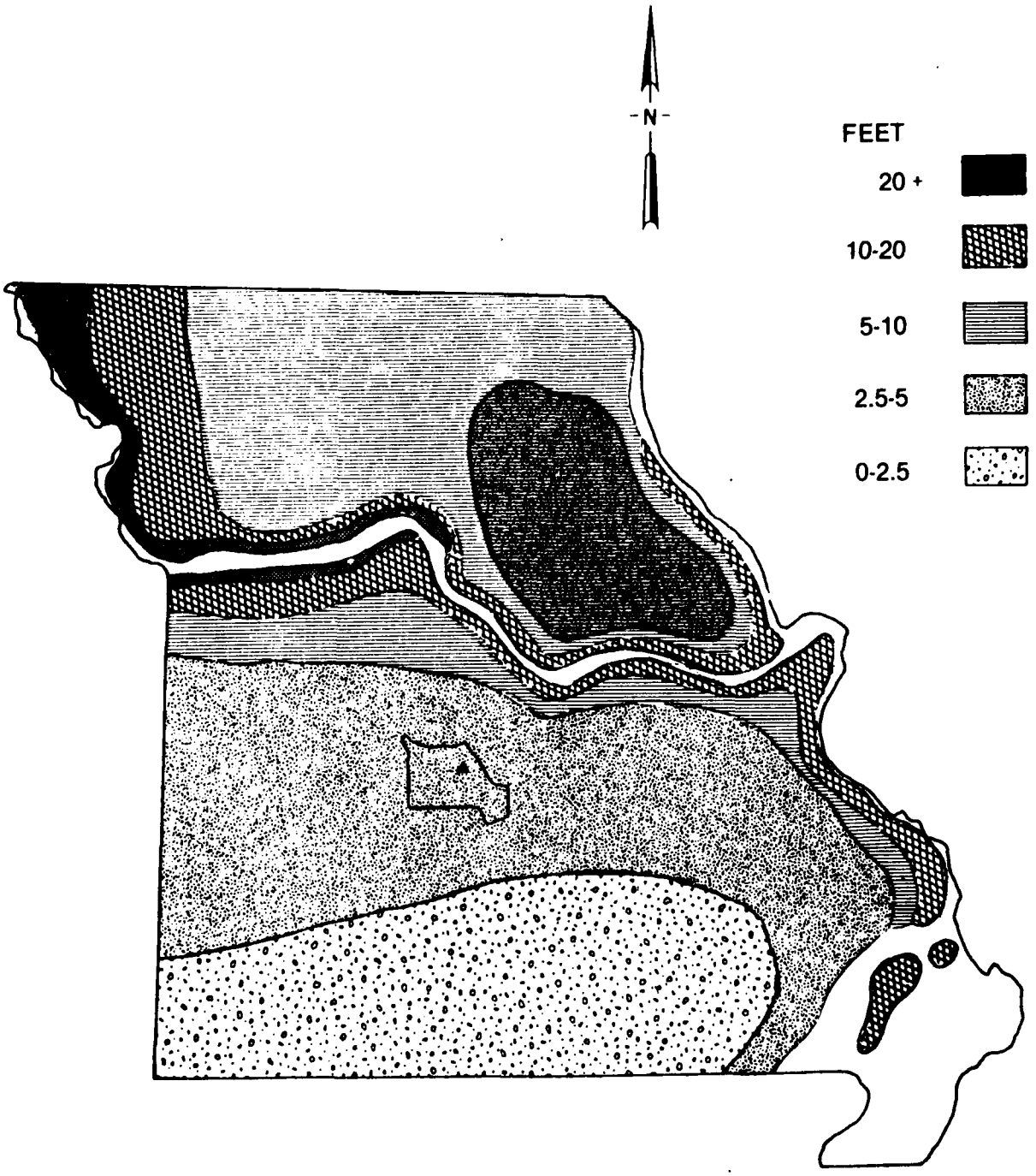
MAJOR GEOLOGIC REGIONS OF MISSOURI

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Burton Duenke #3 Lake Dam
Camden County, Missouri
Mo. I.D. No. 31609

SHEET 1, APPENDIX B



THICKNESS OF LOESSIAL DEPOSITS

HANSON ENGINEERS

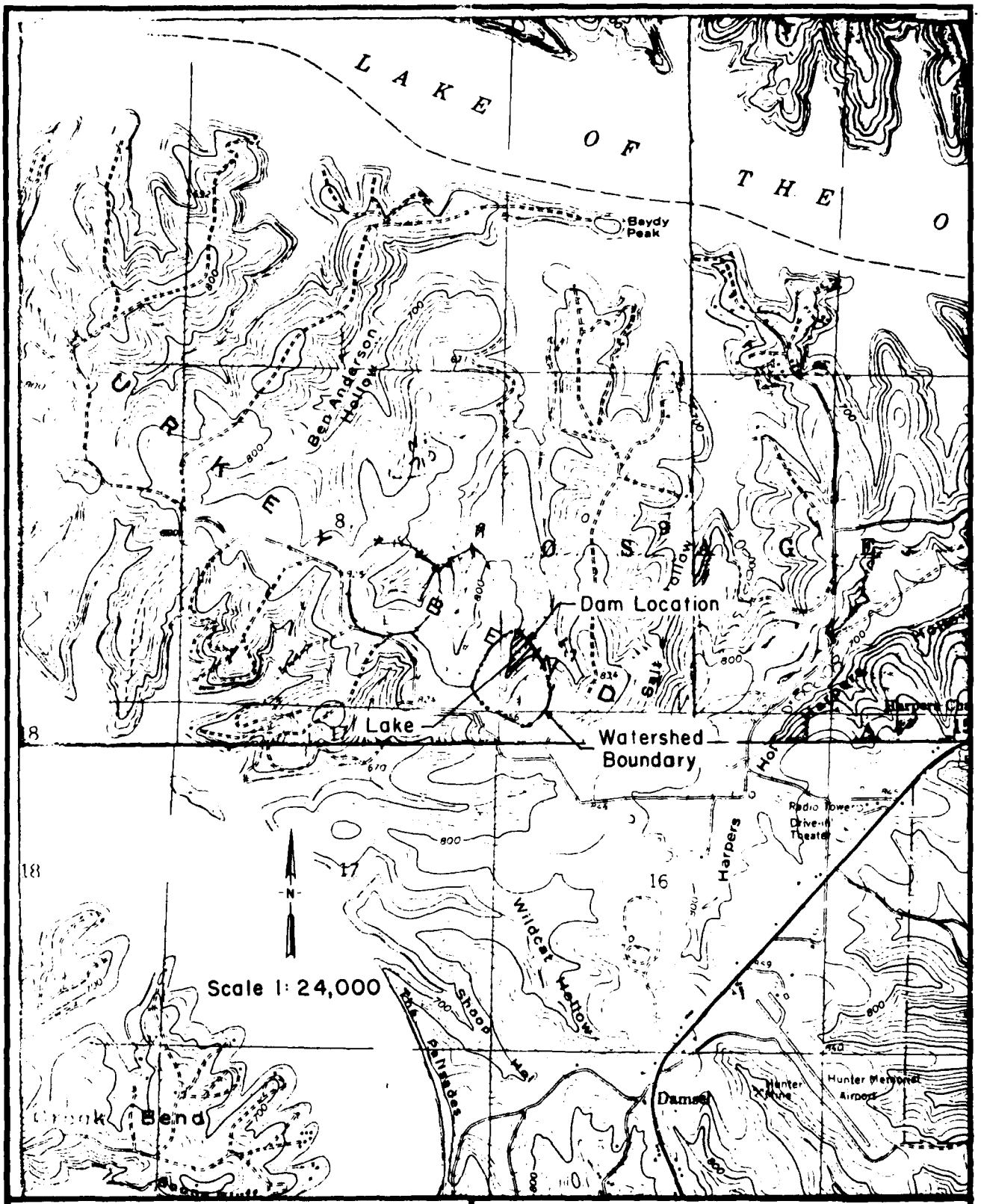
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Burton Duenke #3 Lake Dam
Camden County, Missouri
Mo. I.D. No. 31609

SHEET 2, APPENDIX B

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Burton Duenke #3 Lake Dam
Camden County, Missouri
Mo. I.D. No. 31609

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). Also, the 1 percent chance probability flood was routed through the reservoir and spillway. Warsaw rainfall distribution, as provided by the St. Louis District, Corps of Engineers, was used in this case.

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The parameters for the unit hydrograph are shown in Table 1 (Sheet 3, Appendix C).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2 (Sheet 4, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method. The hydraulic capacity of the spillway was used as an outlet control in the routing. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 4, Appendix C).

The rating curve for the spillway (see Table 4, Sheet 5, Appendix C) was determined using charts for corrugated metal pipe with entrance and full flow-control, from the U.S. Bureau of Public Roads.

The flow over the crest of the dam during overtopping was determined using the non-level dam option ($L and $V cards) of the HEC-1 program. The program assumes critical flow.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 6, Appendix C).

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 7, 8 and 9 of Appendix C.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.042 sq. miles
Length of Watercourse (L)	0.16 miles
Difference in elevation (H)	67 feet
Time of concentration (Tc)	0.06 hours
Lag Time (Lg)	0.04 hours
Time to peak (Tp)	0.08 hours
Peak Discharge (Qp)	254 cfs
Duration (D)	5 min.

Time (Min.)(*)	Discharge (cfs)(*)
0	0
5	242
10	68
15	13
20	3
25	0

(*) From the computer output

FORMULA USED:

* $Tc = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$

$Lg = 0.6\ Tc$

$Tp = \frac{D}{2} + Lg$

$Qp = \frac{484\ A.Q}{Tp}$ Q = Excess Runoff = 1 inch

* NOTE: Other methods of computing Tc yield comparable results.

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	24	33.41	30.66	2.75
1% Prob. Flood	24	7.69	3.70	3.99

Additional Data:

1) Soil Conservation Service Soil Group B
2) Soil Conservation Service Runoff Curve CN = 78 (AMC III) for the PMF
3) Soil Conservation Service Runoff Curve CN = 60 (AMC II) for the 1 percent chance flood
4) Percentage of Drainage Basin Impervious 13 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
756.0	0	0	-
770.0	0.4	3	-
780.0	1.2	11	-
790.0	2.3	28	-
*798.0	3.5	51	0
**801.0	3.9	62	11
802.0	4.0	66	12
806.0	7.0	88	-

*Primary spillway crest elevation
**Top of dam elevation

TABLE 4

SPILLWAYS RATING CURVE

Reservoir Elevation Feet, MSL	Primary Spillway Flow (CFS)
798.0	0
799.0	3
800.0	7
*801.0	11
803.0	14

*Top of dam elevation

METHOD USED:

Charts for corrugated-metal pipes with entrance and full flow control, from the U.S. Bureau of Public Roads, were used.

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (CFS)	Peak Lake Elevation (ft.-MSL)	Total Storage (AC.-FT.)	Peak Outflow (CFS)	Depth (ft.) Over Top of Dam
-	-	*798.0	51	0	-
0.10	79	799.4	56	5	-
0.15	118	800.1	59	7	-
0.20	158	800.7	61	10	-
0.24	189	**801.0	63	11	0
0.25	197	801.1	63	22	0.1
0.30	236	801.2	63	52	0.2
0.40	315	801.6	64	221	0.6
0.50	394	801.7	65	309	0.7
0.75	591	801.8	65	472	0.8
1.00	788	802.0	66	629	1.0

The percentage of the PMF that will reach the top of the dam is 24 percent.

*Primary spillway crest elevation
**Top of dam elevation

```
A       OVERTOPPING ANALYSIS FOR BURTON DUENKE #3 DAM ( # 17 )
A       STATE ID NO. 31609  COUNTY NAME : 029
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 80S3001
B    300                5
B1     5
J      1       9       1
J1   .10     .15     .20     .25     .30     .40     .50     .75     1.0
K      0       1                               3       1
K1      INFLOW HYDROGRAPH COMPUTATION **
M      1       2    .042               .042       1                       1
P      0    25.7     102     120     130
T                                                       -1     -78             0.13
W2  0.06    .036
X      0    -.1       2
K      1       2                               0       4       1
K1      RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                       1       1
Y1     1                                                51      -1
Y4   798     799     800     801     803
Y5     0       3       7      11      14
$S     0       3      11      28      51      66      88
$E   756     770     780     790     798     802     806
$$   798
$B   801
$L   100     257     323     361     390     423     442     461     478
$V   801   801.5     802   802.5     803   803.5     804   804.5     805
K     99
```

PMF Ratios
INPUT DATA

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

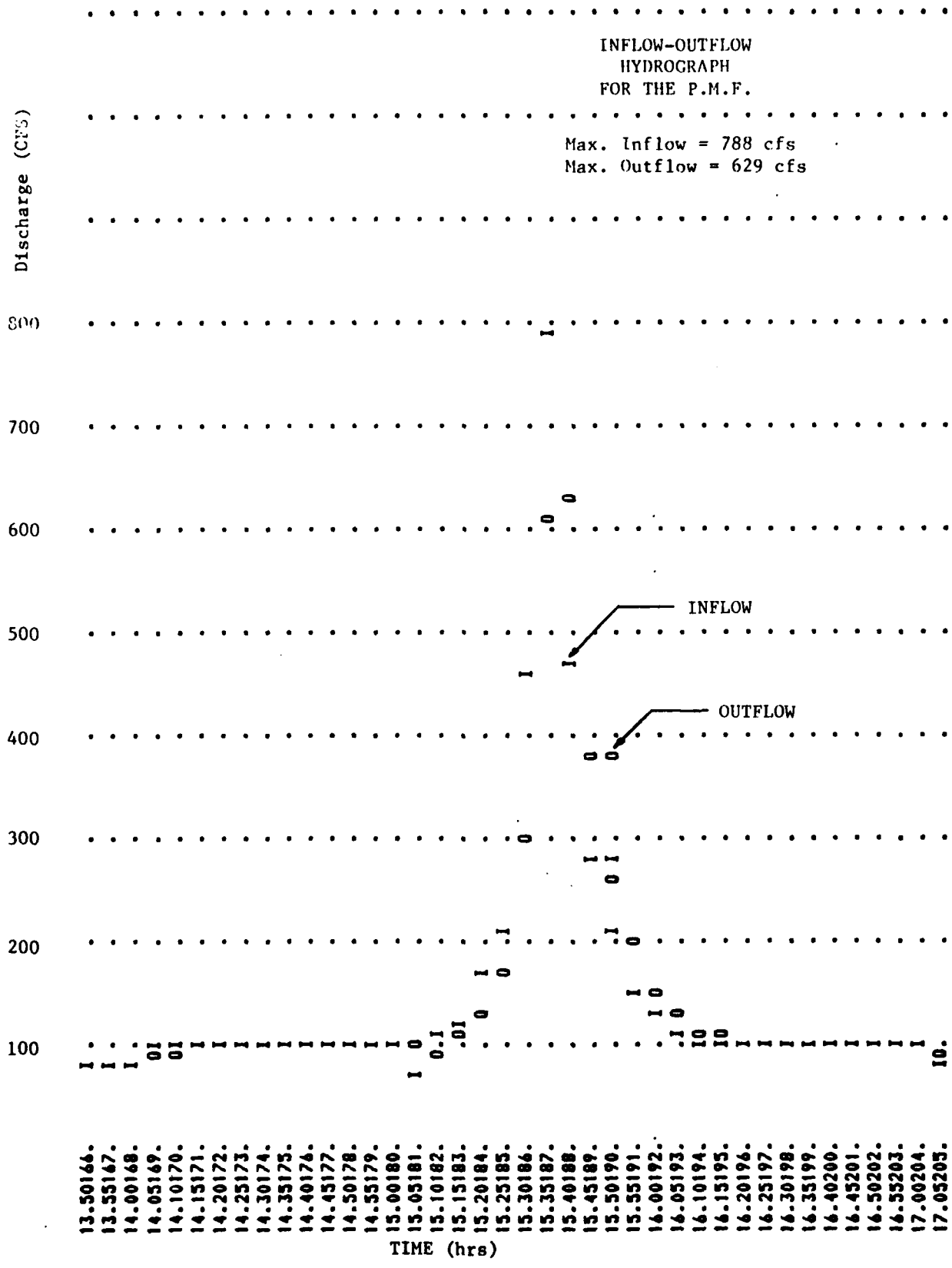
				RATIOS APPLIED TO FLOWS								
OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.75	1.00
HYDROGRAPH AT	1	0.04	1	79.	118.	158.	197.	236.	315.	394.	591.	788.
	(	0.11)	(	2.23)(	3.35)(	4.46)(	5.58)(	6.69)(	8.93)(	11.16)(	16.74)(	22.32)
ROUTED TO	2	0.04	1	5.	7.	10.	22.	52.	221.	309.	472.	629.
	(	0.11)	(	0.13)(	0.20)(	0.28)(	0.62)(	1.49)(	6.24)(	8.75)(	13.36)(	17.81)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	798.00	798.00	801.00
STORAGE	51.	51.	62.
OUTFLOW	0.	0.	11.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.10	799.39	0.00	56.	5.	0.00	18.67	0.00
0.15	800.06	0.00	59.	7.	0.00	18.58	0.00
0.20	800.71	0.00	61.	10.	0.00	18.50	0.00
0.25	801.10	0.10	63.	22.	2.92	17.08	0.00
0.30	801.22	0.22	63.	52.	3.92	15.92	0.00
0.40	801.55	0.55	64.	221.	4.42	15.67	0.00
0.50	801.66	0.66	65.	309.	5.33	15.67	0.00
0.75	801.83	0.83	65.	472.	6.92	15.67	0.00
1.00	801.97	0.97	66.	629.	8.00	15.67	0.00


INFLOW-OUTFLOW
HYDROGRAPH
FOR THE P.M.F.
Max. Inflow = 788 cfs
Max. Outflow = 629 cfs
Discharge (CFS)
800
700
600
500
400
300
200
100
INFLOW
OUTFLOW
13.50166.
13.55167.
14.00168.
14.05169.
14.10170.
14.15171.
14.20172.
14.25173.
14.30174.
14.35175.
14.40176.
14.45177.
14.50178.
14.55179.
15.00180.
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15.10182.
15.15183.
15.20184.
15.25185.
15.30186.
15.35187.
15.40188.
15.45189.
15.50190.
15.55191.
16.00192.
16.05193.
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16.15195.
16.20196.
16.25197.
16.30198.
16.35199.
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17.05205.
TIME (hrs)

APPENDIX D

Photographs

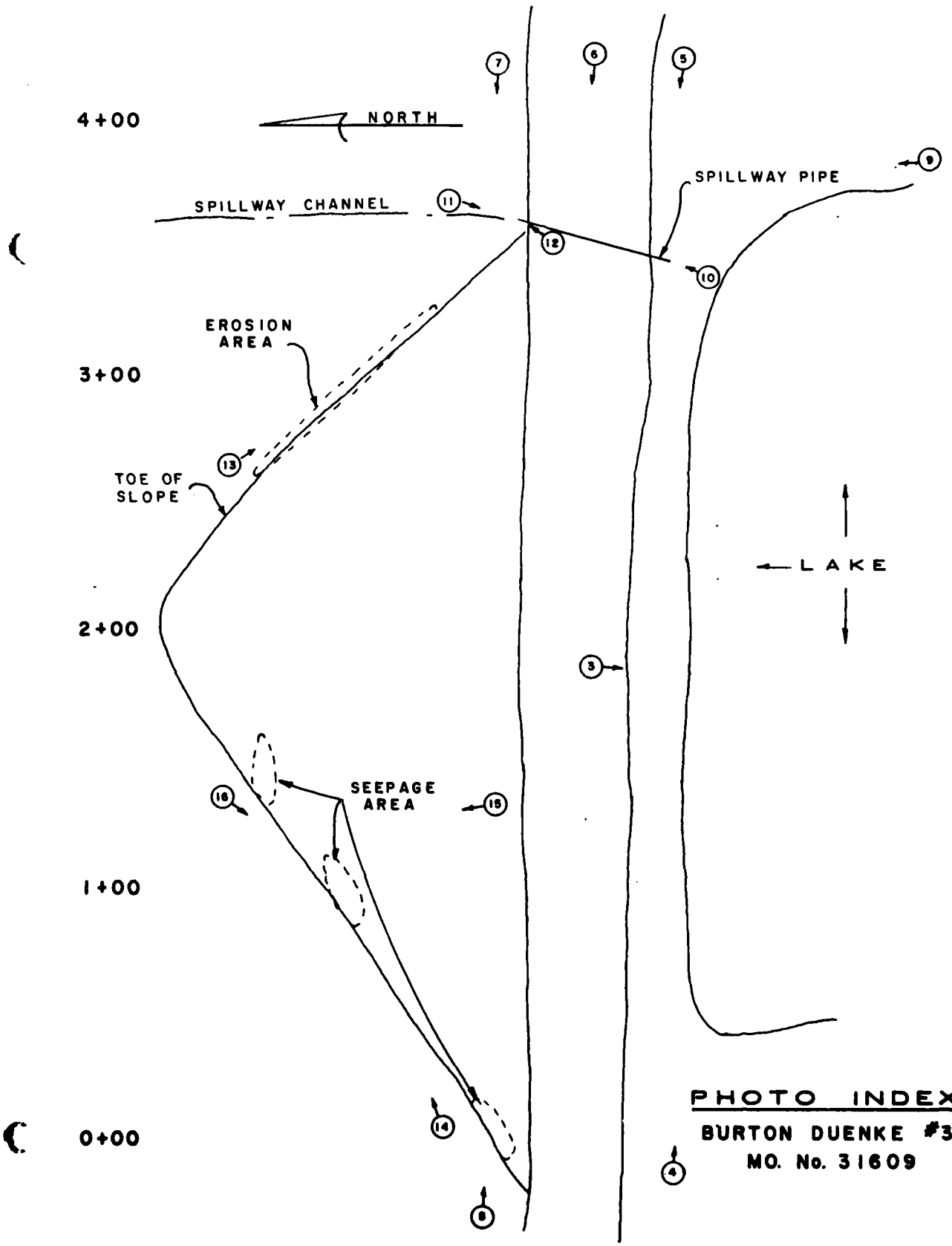


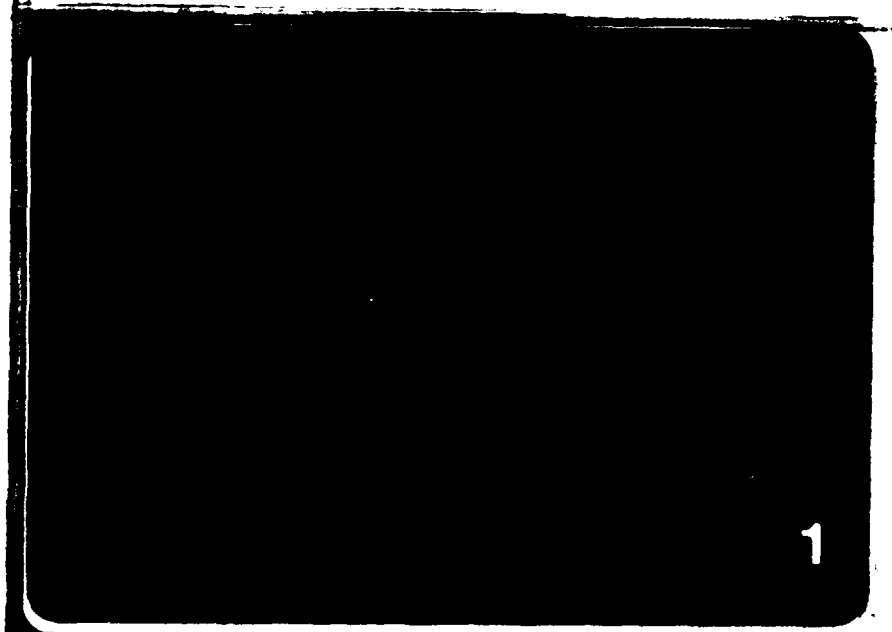
PHOTO INDEX

BURTON DUENKE #3

MO. No. 31609

LIST OF PHOTOGRAPHS

PHOTO NO.	
1	Aerial View of Lake and Dam
2	Aerial View of Lake and Dam
3	View of Lake and Watershed - Looking South
4	Upstream Face of Dam - Looking toward East Abutment
5	Upstream Face of Dam - Looking toward West Abutment
6	Crest of Dam - Looking toward West Abutment
7	Downstream Face of Dam - Looking toward West Abutment
8	Downstream Face of Dam - Looking toward East Abutment
9	Spillway Inlet - Looking North
10	Close-up of Spillway Inlet - Looking North
11	Spillway Outlet - Looking South
12	Spillway Outlet Channel - Looking Downstream
13	Erosional Area at East Abutment - Looking Upstream
14	Marshy Area at Toe - Looking Downstream
15	Marshy Area on Embankment - Looking Downstream
16	Close-up of Seepage Area - Looking Upstream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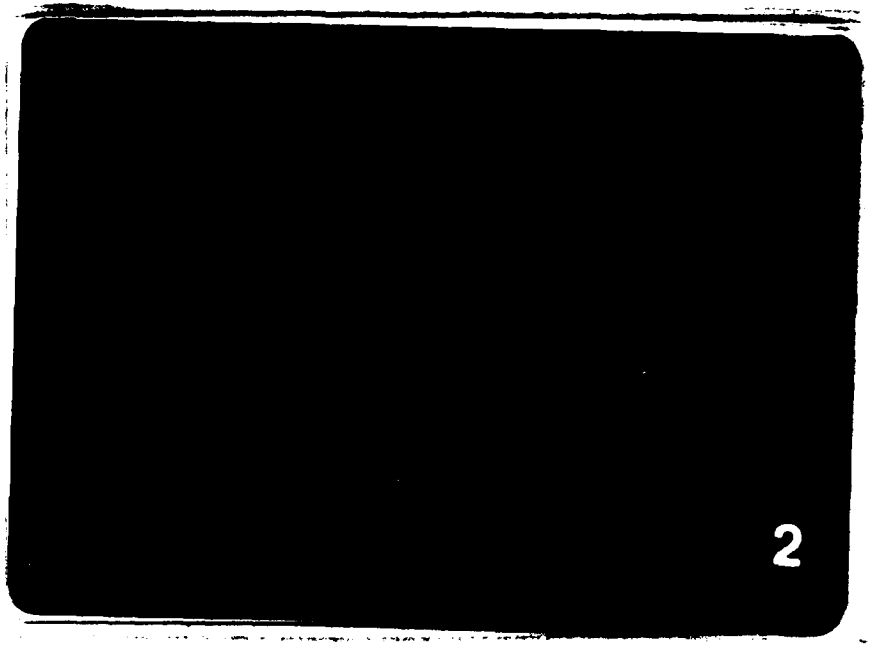
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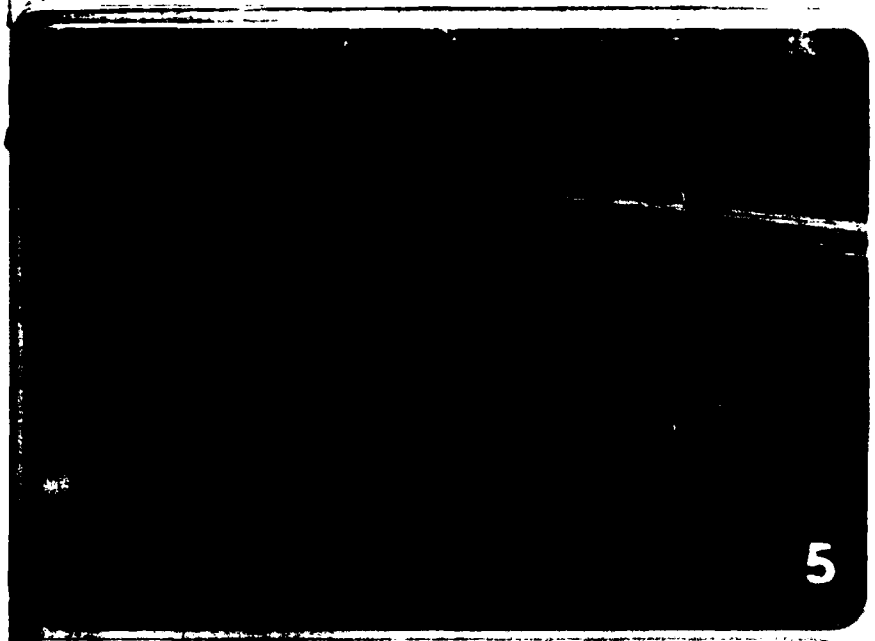
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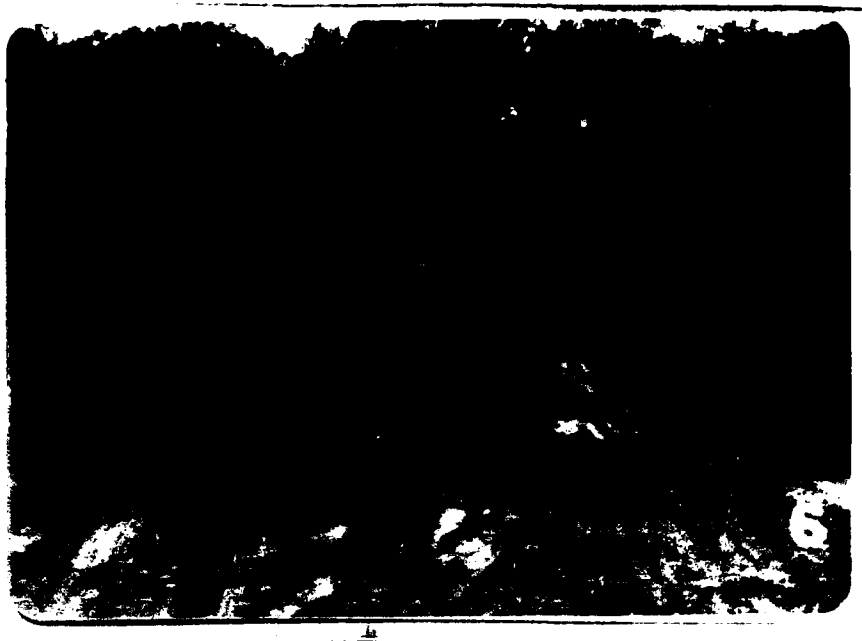
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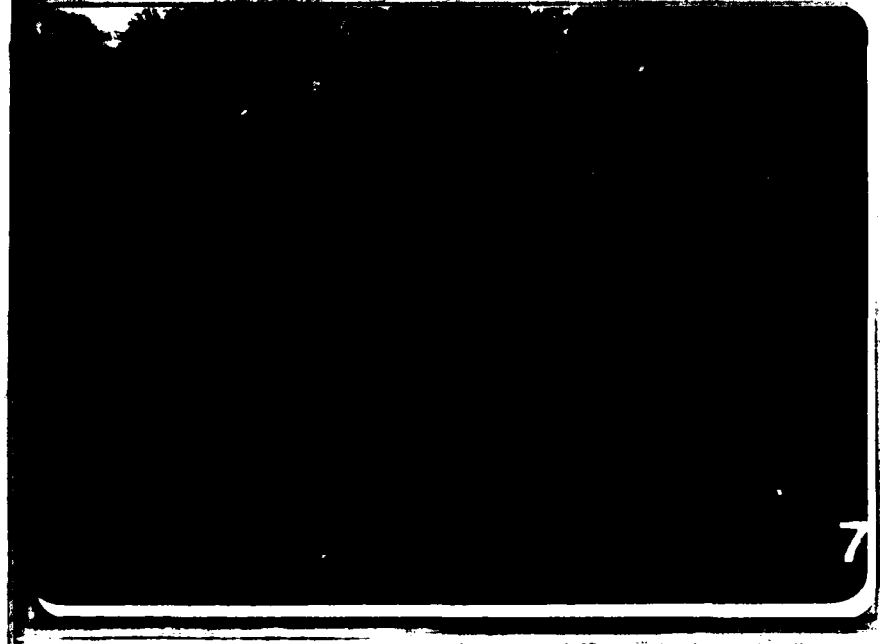
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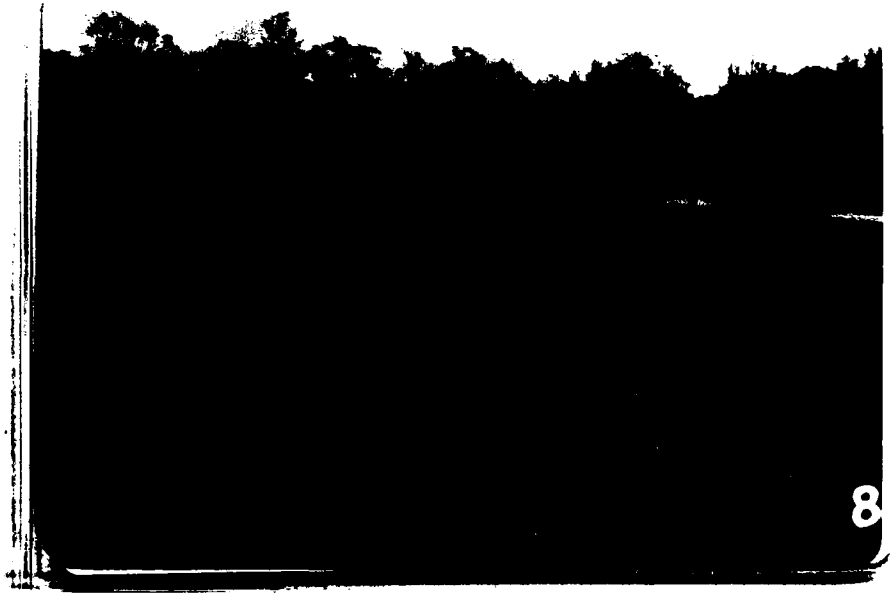
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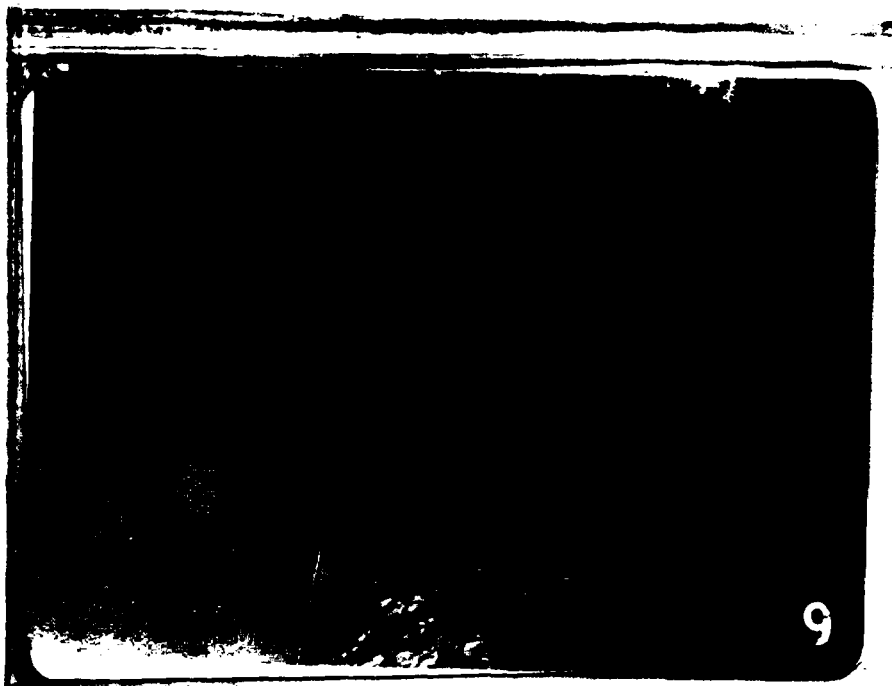
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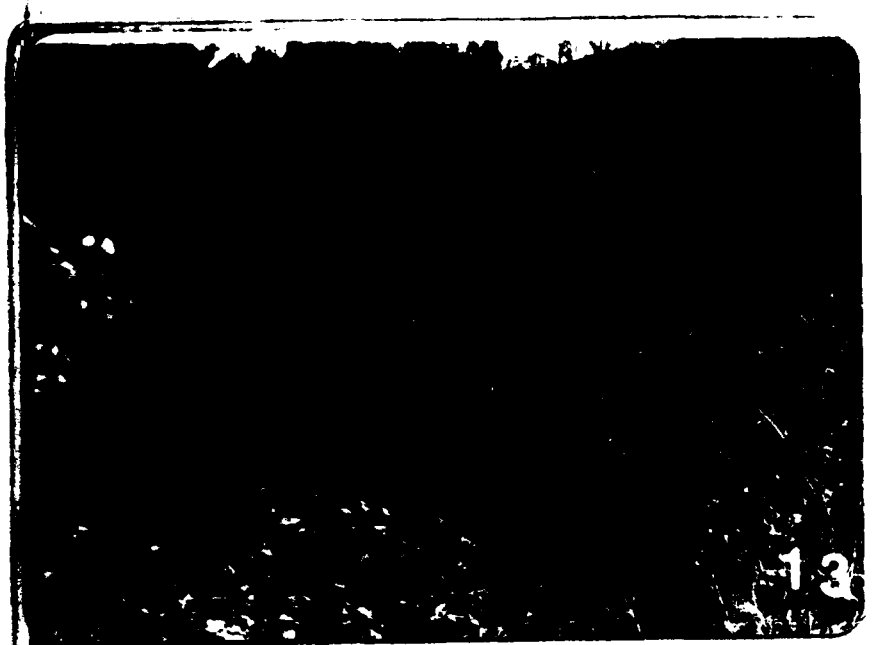
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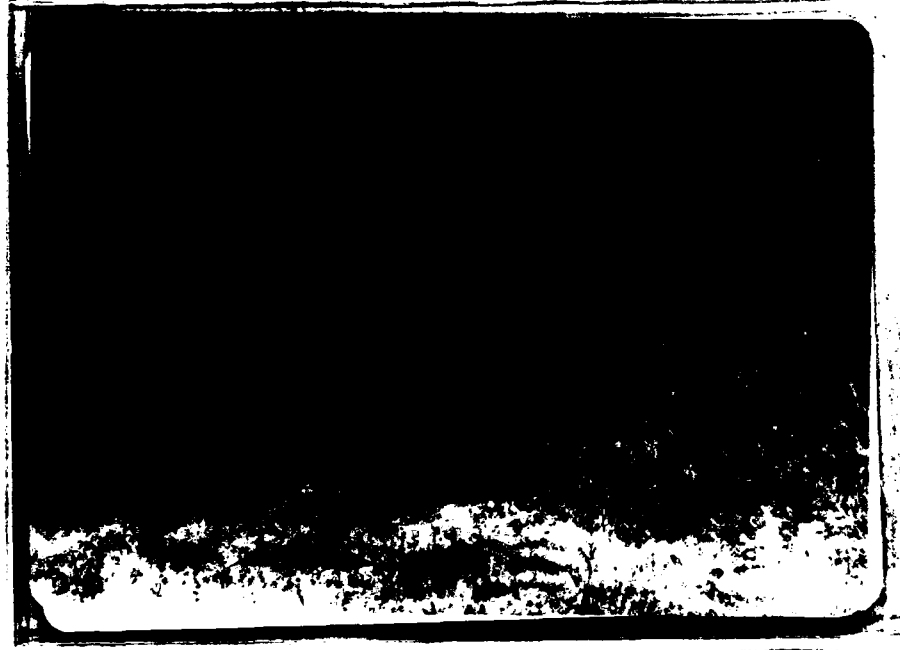


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